

Linkages & Collaborations

CUDOS is built on the excellence of its researchers and the strength of their collaborative links. These links reach across international boundaries and into industry. This diversity of collaborators leads to a rich fabric of interactions between students, academic researchers, and industry partners.

Multi-institutional Publications

We see this reflected in the authorship of our publications during 2011. Of our 73 publications ranked A or A*, less than 30% were written by authors at a single node of the Centre. A significant fraction of the publications were cross node (27%) involved a Partner Investigator (15%), while two publications resulted from collaboration with industry. More than 40% of our publications were with external (non-CUDOS) collaborators. These collaborators are not formally associated with the Centre as are Partner Investigators, but their involvement is testimony to the ground-breaking directions of our program and the international reputations of our Chief Investigators.

Post-deadline Acceptances

Centre research is well-represented at major international conferences. The most prestigious presentations at these meetings are those selected for the post-deadline sessions. These tightly-refereed plenary sessions are reserved for presentations of recent research at the cutting edge of the field which has not been published or previously disclosed, and as such attract significant interest. Centre researchers gave six post-deadline presentations during the year, a strong performance that exceeded our ARC-agreed target.

Annual CUDOS Workshop

Our Annual Workshop is a crucial mechanism for cementing collaborative links within the Centre. In 2011 we were delighted to welcome all but four of our fifteen Partner Investigators including almost all of our new Partner Investigators including our industry PIs to what was, in effect, the kick off for the Centre's seven-year research program. Over 150 attendees attended our 2011 Workshop, making it one of the largest gatherings of photonics researchers in Australia outside of the biennial ACOFT meetings.

All CUDOS Staff, Students, Investigators and Invitees at the 2011 Annual CUDOS Workshop

Invited Talks, Visits to Overseas Laboratories and International Visitors to the Centre

Engagement of the Centre's researchers with their international colleagues is also exemplified by the attendance of CUDOS researchers as invited and plenary speakers at major international conferences and workshops. A full listing of all Invited Talks and Papers can be found at the end of this report.



Ben Eggleton – Plenary Speaker, International Symposium on Photonics and Optical Communications, Chengdu, China, July 2011

A visitation program that involves CUDOS members' visits to overseas institutions and visiting researchers to all nodes of the Centre reinforces the importance of international collaboration, which in turn provides opportunities to build intellectual exchanges and strategic alliances. CUDOS researchers and students visited over 50 international laboratories in 2011, in countries as diverse as PRC, Taiwan, Sth Korea, USA, Finland and Germany. Conversely, CUDOS attracts distinguished visitors from around the globe and the table on the next page demonstrates the diversity of researchers who were hosted in 2011, their engagement ranging from short visits to semester long appointments as Visiting Scholars.



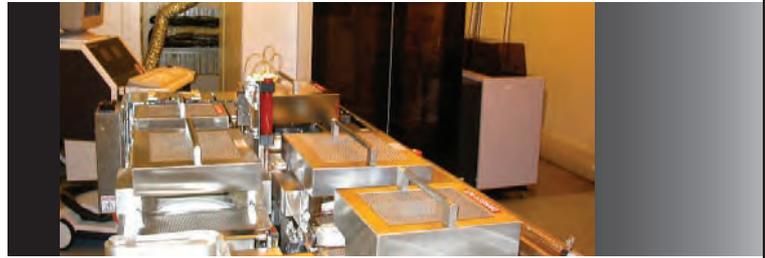
Industrial Collaborations

Nanofabrication will be core to the Centre's programs in metamaterials and nanoplasmonics, and of ongoing importance to our photonic chip-based research in mid infrared and terabit photonics. Much of this work relies on the fabrication of patterned structures with feature sizes of hundreds on nanometres but over field sizes of centimetres square. Electron beam lithography can achieve this but the time taken to 'write' this pattern can take days. Optical projection lithography, in which light is transmitted through a mask with the desired pattern and imaged onto a photosensitive substrate, accomplishes the same operation in minutes. Furthermore, this pattern can be 'stepped' and imaged multiple times over a large substrate.

No optical 'stepper' was available in Australia prior to 2010, when Centre researchers played a lead role in a successful proposal to the Australian National Fabrication Facility (ANFF) for the establishment of an optical lithography facility at Bandwidth Foundry International. The facility, which is now installed and operating for national access, is built around an 'i-line stepper' manufactured by ASM Lithography. The tool is capable of writing feature sizes of one half a micrometre over field sizes of 20 mm square and is being used by Centre researchers to produce waveguide structures for Flagship projects.

CUDOS researchers have also built up strong working

I-Line Stepper at the Bandwidth Foundry



relationships with the ANFF nodes at the ANU and at the University of NSW. The latter node has a high performance electron beam system for writing devices with feature sizes smaller than that achievable with the i-line stepper, photonic crystals for example.

International Collaboration

The Centre continues its formal collaboration with the European Union project SOFI (<http://www.ihq.uni-karlsruhe.de/research/projects/SOFI/>), a strategic program of research across six European partners and only one non-European participant, CUDOS. The aims of the project are very synergistic with those of the Centre. SOFI focuses on a proof-of concept implementation of ultra-fast ultra-low energy optical phase modulator waveguides for optical communications, with an ultimate aim of demonstrating an integrated circuit to aggregate low-bit rate electrical signals into a 100 Gbit/s OFDM data-stream with energy consumption of only 5 fJ/bit.

VISITOR	ORGANISATION	COUNTRY
Dr Pavel Below	NRU of Information Technologies, Mechanics and Optics	Russia
Prof Mark Digman	Queens University	Canada
Mr Falk Eilenberger	Friedrich Schiller University of Jena	Germany
Prof Valentin Freilikher	Bar-Ilan University	Israel
Dr Nicolas K Fontaine	University of California, Davis	USA
A/Prof Michael Galili	DTU Fotonik	Denmark
A/Prof Hans Christian Hansen Mulvad	DTU Fotonik	Denmark
Prof John Harvey	The University of Auckland	New Zealand
Prof Sergei Kozlov	St Petersburg State University of Information Technologies, Mechanics and Optics	Russia
A/Prof David Lancaster	University of Adelaide	Australia
A/Prof Matthieu Lancry	Université Paris-Sud	France
Dr Jianfeng Li	School of Optoelectronic Information, University of Electronic Science and Technology of China (UESTC)	P. R. China
A/Prof Feng Luan	Div. of Communication Engineering, School of Electrical and Electronic Engineering, Nanyang Technological University	Singapore
Prof Michel Marhic	MNC, College of Engineering, Swansea University	UK
Dr Christelle Monat	Ecole Centrale de Lyon, Lyon Institute of Nanotechnology (NL)	France
Dr Amir Nejadmalayeri	MIT	USA
A/Prof Willie Padilla	Department of Physics, Boston College	USA
Prof Sir John Pendry	Imperial College London	UK
Dr Alexander Poddubny	NRU of Information Technologies, Mechanics and Optics	Russia
Mr Christian Reimer	Microphotonics and Photonic Crystals Group, University of St Andrews	Scotland
Dr Roland Schiek	University of Applied Sciences Regensburg	Germany
Dr Xiang Shen	Ningbo University	P. R. China
Dr Jurgen van Erps	Vrije Universitet Brussel	Belgium
Dr Anna Vozianova	NRU of Information Technologies, Mechanics and Optics	Russia
Dr William Wadsworth	University of Bath	UK
Prof Alex Zharov	Russian Academy of Sciences	Russia
Dr Nina Zharova	Russian Academy of Sciences	Russia

Outreach & Public Awareness

Outreach

The outreach mission for CUDOS is to promote and present CUDOS, its researchers and its research activities to the general public, to school students and teachers, and to relevant government, professional and industry organisations. In 2011 CUDOS continued to foster a considerable number of programs and activities relating to outreach and public awareness, with the objective of improving the visibility, understanding and appreciation of the Centre and photonics research.

Delivering Outreach

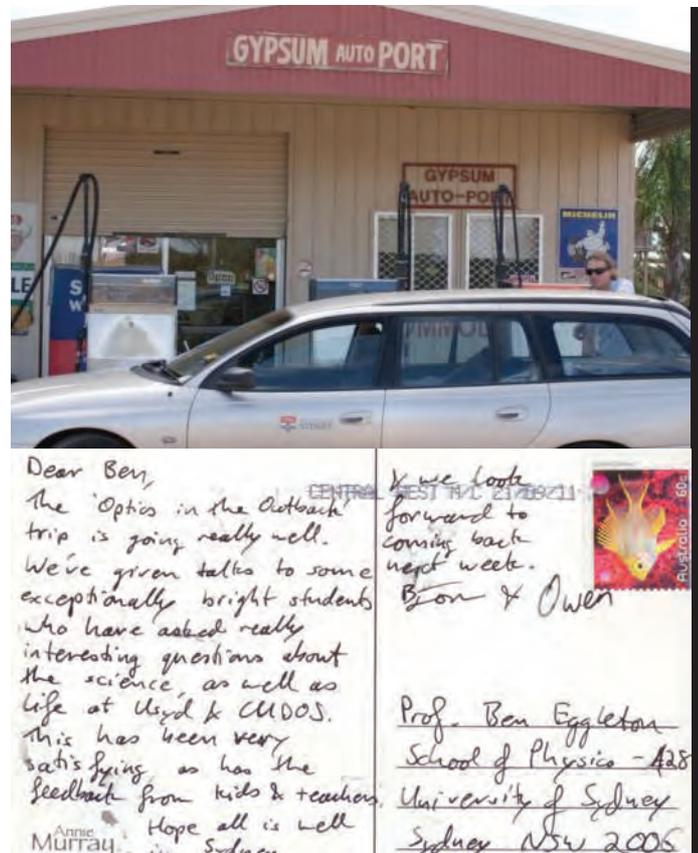
In recognition of the need to build upon and expand the current suite of outreach initiatives, and to facilitate its implementation across the different CUDOS nodes, the CUDOS Outreach and Education & Training Committee was formed in 2011. The committee is co-chaired by Judith Dawes, Outreach Coordinator, and Jochen Schröder, Director of Education & Training and includes a staff member from each node. The committee will hold its inaugural meeting at the Annual CUDOS Workshop in early 2012 and its first item of business is to identify new outreach opportunities for different nodes, and to coordinate outreach activities between nodes. Future activities planned include a CUDOS Showcase for teachers & students, industry and government and a summer/winter school for university students.

Composition of the committee is

- Dr Madhu Bhaskaran, RMIT
- Dr David Powell, ANU-NLPC
- Dr Liang Du, Monash University
- A/Prof Judith Dawes, Macquarie University (Co-Chair)
- Dr Jochen Schröder, The University of Sydney (Co-Chair)
- Dr Khu Vu, ANU-LPC
- Dr Chris Poulton, UTS

School Outreach

Significant outreach to school students and school teachers by CUDOS staff and students occurred in 2011. The highlight of this activity was the *Optics in The Outback* tour undertaken by students Owen Brasier and Björn Sturmberg of the University of Sydney; they covered a large area of the Riverina, Western and North-Eastern NSW, visiting 11 schools in their tour, speaking to approximately 450 school students in years 8-12. They gave hands-on demonstrations, class talks, and informal discussions about studying at university, photonics, optics and light for telecommunications. The need for internet access in regional NSW was a key topic of discussion by the students.



Optics in the Outback Tour



The Laser Telephone

Additionally, workshops and talks for school students in Metropolitan Sydney on the CUDOS Photonic simulator, the "laser telephone", "laser maze", "laser graffiti" as well as hands-on demonstrations of lasers and optical fibres were conducted for students from independent and government high schools (Barker College, Hills Grammar School, MLC School, Roseville College, Hornsby Girls High School, Penrith High School, Gosford High School, St Ignatius College Riverview, Masada College, Marist Sisters, Mackellar Girls High School, Wenona, Meriden, the Peninsula Community of Schools, Marian College, Ku-ring-gai High School, Abbotsleigh School). CUDOS staff and students talked to more than 600 students in years 10-12. The Photonics simulator offers a web-based computer simulator to show students how a telecommunications network can be constructed, and it includes real engineering effects such as attenuation in the optical fibres. The simulator was Highly Commended in the Engineering Excellence awards in 2009. The laser maze and laser telephone are fun, interactive activities, which convey key ideas of light carrying signals coded as digital information. Students and their teachers enjoy the laser maze in which a laser beam is modulated by music signals, and as the students navigate their way through the darkened room, blocking the laser beam stops the music!

During the CUDOS Workshop in Shoal Bay 2011, students from Years 11 and 12 Tomaree High School interacted with CUDOS staff and students – enjoying a talk and demonstration on optics as well as helping to judge the 2011 CUDOS Student Outreach Competition.

The Science Experience is a nationally organised event held in Universities around Australia to engage year 9-11 students in Science lectures and activities. The activities at ANU and Macquarie included specific Photonics lab based activities, for example giving students hands-on experience handling laser diodes and polymer optical fibres, teaching them about fluorescence in fibre lasers.

Science in the City, an initiative of the Australian Museum with The University of Sydney as an Executive partner, provides school students from across Sydney an opportunity to engage first-hand with a wide range of science activities – workshops, shows, talks, tours – to celebrate National Science Week. PhD students from CUDOS Sydney participated in photonics demonstrations.

Each year, Macquarie University celebrates *Women's Day* by promoting talks and activities for Women in Science. The CUDOS group provides hands-on demonstrations of optics and photonics phenomena to female students who are invited from Sydney schools.

Outreach & Public Awareness Continued

Public Awareness

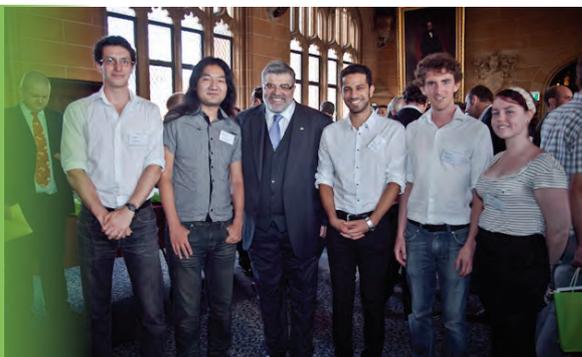
Public awareness generated by the Centre is an indicator of its interaction and visibility outside academia. Public awareness activities in 2011 ranged from the official launch of CUDOS, public talks and industry/government briefings given by staff, media releases and interviews, and recognition of staff achievements through the award of prizes and other accolades.

CUDOS Launch

CUDOS was launched in fine style when the (then) Minister for Industry, Innovation, Science and Research, Senator Kim Carr, visited the University of Sydney on April 6 2011 and launched CUDOS with about 200 invited guests in the audience, who enjoyed watching the CUDOS movie presenting the key researchers and research themes of CUDOS. The CUDOS movie is now on You-tube! http://www.youtube.com/watch?v=830YgQ_C9fY. Prior to the Launch, Minister Carr undertook an extensive tour of the CUDOS Sydney Labs and talked with students and staff, thus providing an opportunity for the Minister to be briefed on the research platform that underpins the Centre's activities.



The CUDOS Launch on 6 April at The University of Sydney



Minister Carr meets CUDOS students

Industry & Government Briefings

The Centre actively promotes its activities and encourages potential investment and collaboration through briefings to government agencies and industry representatives. Examples of these briefings in 2011 included

- Lectures and lab demonstrations by CUDOS staff to the ANU Research School of Physics and Engineering Development Board, providing a forum for the promotion of the key highlights of CUDOS research at the highest levels of ANU governance.
- Prof Arnan Mitchell participated in the *Annual Science meets Parliament*. This event brings 200 scientists from all over the country face-to-face with Parliamentarians in Canberra thus providing them with unparalleled opportunities to witness national decision making at first hand, and to inform this process on important scientific issues.
- Professor Ben Eggleton was the keynote speaker at *Big Picture Science Dinner* held at The University of Sydney to discuss the exciting potential that nanoscience offers NSW and Australia. The 16 guests included NSW Chief Scientist and Scientific Engineer, Professor Mary O'Kane, plus industry, government and science leaders. Prof Eggleton spoke about the nanoscience conducted by CUDOS, the landscape of research and industry in NSW, and how the new state government could engage more effectively with the research and industry community in NSW.

Public Talks & Media Coverage

A number of public talks were delivered by Centre researchers in Australia and overseas in 2011. For example Prof Min Gu gave a public lecture on *Transformational Nanophotonics* at the Wuhan National Laboratory for Optoelectronics, PRChina. Prof Ross McPhedran spoke on *Some Useful Physics* at the Australian Institute of Physics, NSW Branch.

Prof Yuri Kivshar was invited on many occasions to address the media, including national and international interviews and commentaries. For example, he spoke on ABC Science and gave a web interview on Science & Technology in Russian

Federation STRF. Dr Nem Jovanovic was interviewed on Western Plains radio about the innovative work he is carrying out at the Anglo-Australian Telescope with the new photonic instrument.

In 2011 The Centre was the subject of two media releases put out by the University of Sydney; one relating to the Launch of CUDOS and the other to the groundbreaking research in quantum light source being carried out across the Centre. These sparked significant media interest and generated a number of national & international magazine and newspaper articles, in addition to over one hundred web stories. In 2012 CUDOS will work to proactively increase generated media coverage that reflects progress in research. CUDOS has engaged the services of a Media Monitoring Agency to track where and when the Centre and its researchers are generating press. This will enable us to identify interested publications to which press releases can be sent, thus increasing coverage and the awareness of the centre.

Website

CUDOS commissioned a new website in 2011 and it is still considered a work in progress. The Centre did not meet its KPI for number of website hits in 2011 (the webstat feature was not operational until October so the statistic has been extrapolated from the available data). We have however identified a number of strategies that should enhance web traffic flow, which will be implemented in 2012. We also intend to explore the use of new media as a tool for delivering engagement and awareness; eg development of a Facebook site and/or blog posts to provide an on-line platform for the sharing of information and discussion.

Public Recognition

2011 has again been marked by the recognition of many Centre members' achievements, thus facilitating CUDOS' aspiration to be a flagship of Australian science and the national authority on photonics.

For his leadership in establishing CUDOS and for the vast body of research he continues to contribute to the field, **Professor Ben Eggleton** was awarded the **2011 Eureka Prize for Leadership in Science**, the most prestigious award in Australian science. The \$10,000 prize is awarded to an Australian individual who has demonstrated an outstanding role and impact in science. "...His strong leadership of the CUDOS multidisciplinary research centre has seen it become a leading force on the international scientific stage, and means his impact on Australian science will be felt for many years to come." said Frank Howarth, Director of the Australian Museum. Prof Eggleton was also the winner of the **2011 AIP Walter Boas Medal**, awarded for excellence in physics research carried out in the previous five years.

A/Professor David Moss was awarded the **2011 Eureka Prize for Innovation in Computer Science** for his breakthrough work incorporating light on to silicon computer chips.

Dr Boris Kuhlmeiy was a recipient of the **NSW Young Tall Poppy Science Award** by the Australian Institute of Policy and Science in recognition of his achievements.

Prof Min Gu was awarded the **WH (Beattie) Steel Medal** from the Australian Optical Society. Considered Australia's most prestigious award in optics, the medal recognises Professor Gu's strong and sustained record of authority, enterprise and innovation in the field of optics.

Prof Ross McPhedran was elected as a **Fellow of the Australian Academy of Science** in recognition of his distinguished research in wave science leading to improved performance in microstructured optical fibres, diffraction gratings and photonic crystals.